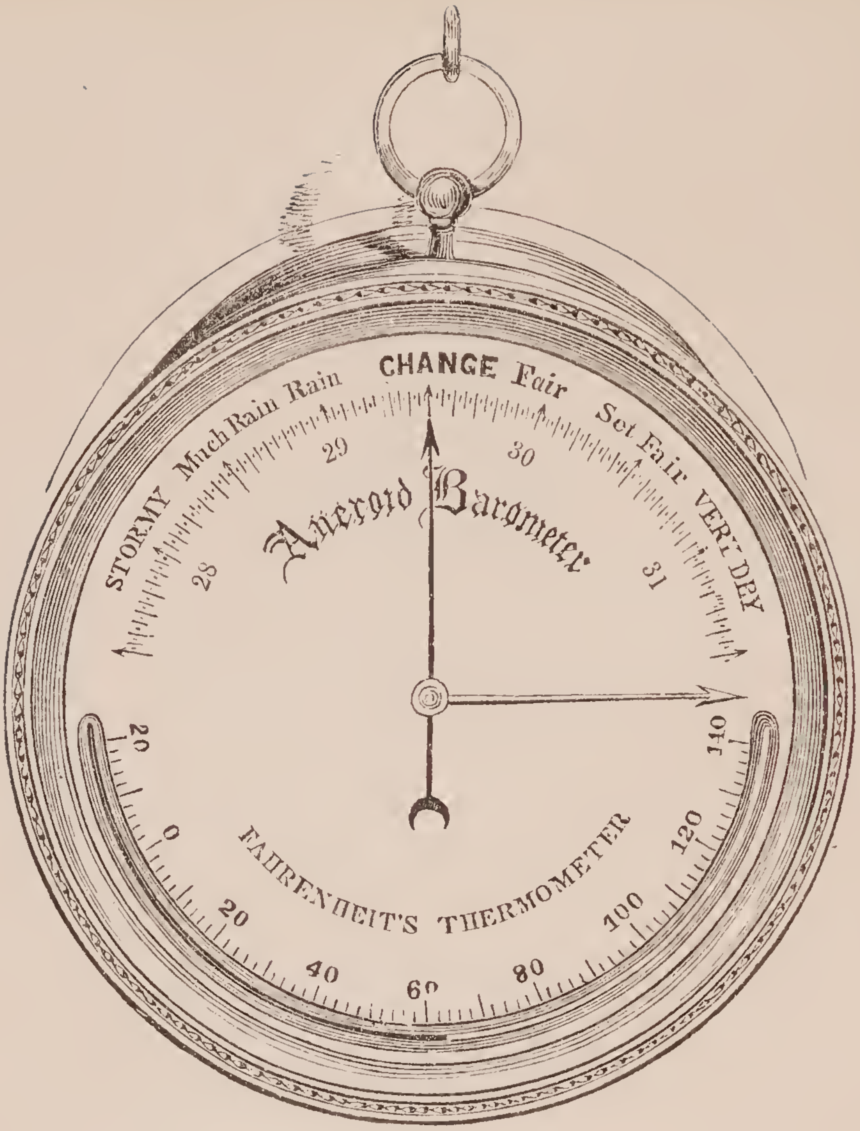
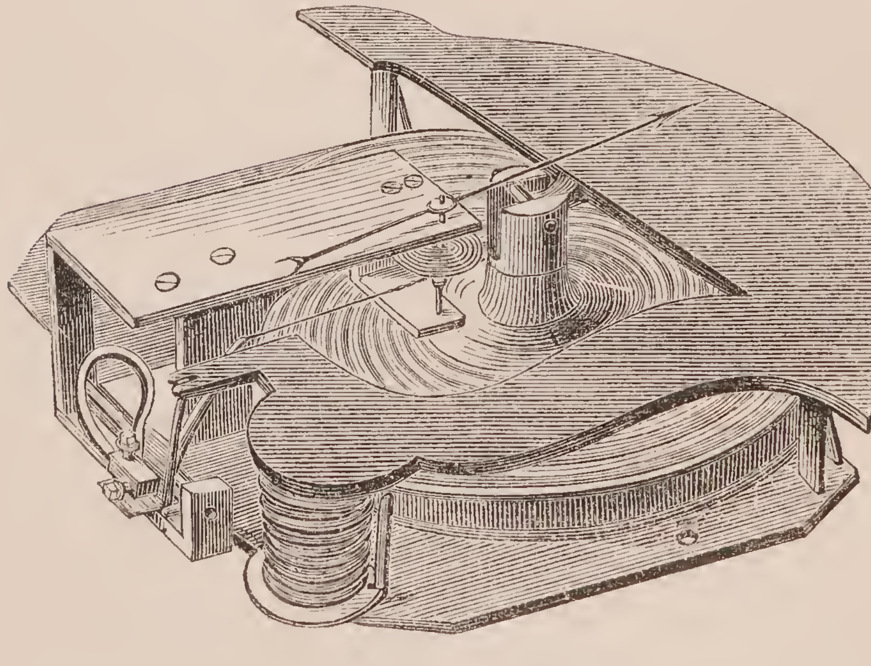
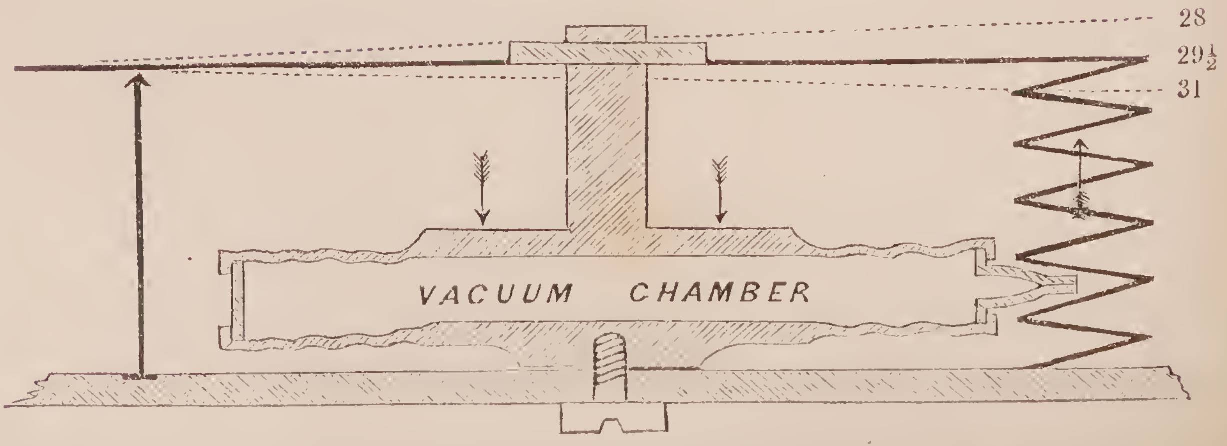




View of the Interior.



Motion of the lever caused by changes of pressure upon the vacuum chamber.

5

A FEW REMARKS

UPON THE

CONSTRUCTION AND PRINCIPLES OF ACTION

OF THE

ANEROID BAROMETER,

WITH

OBSERVATIONS ON THE MERCURIAL BAROMETER,

BY

CHARLES FRODSHAM, F.R.A.S., Assoc. I.C.E.
CHRONOMETER, WATCH, AND CLOCK MAKER.

Arnold's,
84, STRAND, CORNER OF CECIL STREET.

LONDON:
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1849.

[*Price One Shilling and Sixpence.*]

ERRATA.

Page 8, line 9, for, "amount," read, *may* amount.
13, ,, 20, for, "and when confined," read, for *air*, when confined.
19, last line but one, for, "100°—40°," read, 100°—60°
22, line 3, for "+47," read, —47; for, "603," read, —509
,, ,, 4, for, "905," read, 999.

ADDENDA,

Referring to pages 21 *and* 22.

It has been thought desirable to state that the table of altitudes given at page 21, has been calculated for the mean temperature of our climate, viz. 55° of Fahr.; and further, that as it will sometimes happen that the mean temperature of the two observations will differ considerably from 55°, the following rule for a correction may be applied to the result given by the table where strict accuracy is required.

Rule.—Note the temperature at the two altitudes at the time of taking the barometer readings, and take a mean thereof; then having obtained the elevation by means of the table, add $\frac{1}{435}$th part of that result for each degree that the mean temperature is above 55°, or subtract $\frac{1}{435}$th part for each degree that the observed mean is below 55°, and the result thus corrected is the elevation required.

A correct result may also be obtained independently of any table by the following simple formula, given in Hutton's Mathematics, Vol. II., § 278. Let B be the lower barometric reading and b the upper, then the altitude in feet $=\frac{B-b}{B+b}\times 55{,}000$.

Taking the Example given at page 22, we have $\frac{B-b}{B+b}\times 55{,}000=\frac{29{\cdot}53-28{\cdot}48}{29{\cdot}53+28{\cdot}48}\times 55{,}000=\frac{1{\cdot}05}{58{\cdot}01}\times 55{,}000=996$ feet, nearly the same as that given by the table.

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A FEW REMARKS

UPON THE

ANEROID BAROMETER.

This little philosophical instrument, of only five inches in diameter, is well worthy of the attention which has been bestowed upon it by the public, on account of its portability, sensitiveness to atmospheric changes, and the general accuracy of its determinations, both as regards changes of weather, and in the admeasurement of heights and differences of level, which it accomplishes without the necessity for those complex corrections for temperature which enter into the computation when the mountain barometer is employed for that purpose. The Aneroid displays much ingenuity, both in its principle and arrangement; and the nice adaptations and contrivances it contains, warrant the conclusion that it is the happy emanation from a fertile and ingenious mind. Perhaps nowhere are the indications of the Aneroid more striking than when travelling upon a railroad, where the traveller will observe the hand mark, distinctly, every gradient that he meets with as the train proceeds.*

---

* It was during the author's experiments upon the Brighton railroad, that he first became convinced of the sensitive nature of the Aneroid, in denoting the transition from one level to another.

It must not, however, be supposed that the Aneroid is without its defects; for the mechanism, although skilfully carried out in its arrangement, is wanting in steadiness, as well as subject to uncertain amounts of friction. A peculiarity has also been remarked in its possessing a susceptibility to slight aberrations from sudden changes of temperature: exposed to sudden cold, it falls, and rises at the approach of heat; and the deviation resulting from a difference of temperature of 30 or 40 degrees of Fahrenheit, amount to the tenth of an inch, as will be shewn by experiment further on. It is, nevertheless, a valuable adjunct to the barometer and to science. For ordinary use I prefer the Aneroid to the common barometer, on account of its portability; but for the purposes of nice philosophical experiment, the mountain barometer, like the marine chronometer, remains unrivalled.

The following is an outline of its Construction and Mode of Action.

The Aneroid belongs to that class of instruments which are termed differential, and may be described as consisting of three parts: a chamber partially exhausted of air,—a helical spring,—and a system of levers, which direct the motion of the hand.

The chamber is of a cylindrical form, about 2¾ inches in diameter, and 5-16ths of an inch deep, partially exhausted of air and hermetically sealed. The surface is composed of thin corrugated copper plates:—and it is by this peculiarly felicitous contrivance that they acquire the faculty of rising or falling with every variation of atmospheric pressure.

The helical spring is formed of steel wire of about

1-20th of an inch in thickness, and is consequently a strong one: when in the instrument it is about 1 inch high and 5-8ths of an inch in diameter.

The chamber and the spring are brought into connection with a main lever, which falls or rises according to the increased or diminished amount of atmospheric pressure sustained by the chamber, and counterbalanced by the spring. This is a fundamental principle of the instrument, and must not be lost sight of.

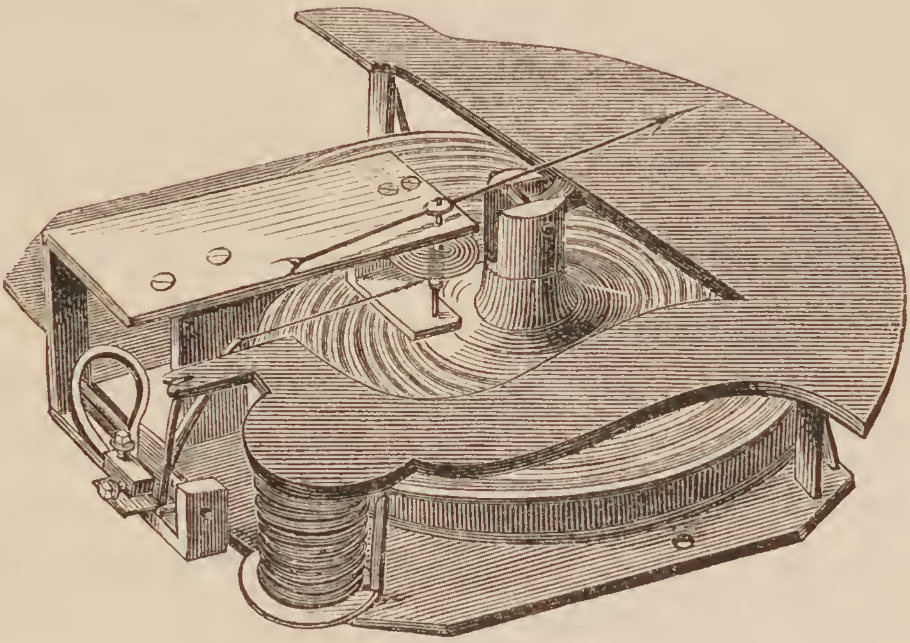
The system of levers is employed to multiply the movement of the main lever, of which we have just spoken; and to the ultimate lever is attached a fine watch-chain, which passes round a roller fixed upon the arbor that carries the hand, which indicates the changes of atmospheric pressure upon a graduated dial. A delicate spiral spring is also fixed upon the same arbor, for the purpose of keeping the hand steadily in its place and the chain in a state of tension.

The chamber has been styled a "vacuum vase:" but the term is rather inappropriate, inasmuch as a vacuum does not exist, nor has the air-pump (which is stated to be the means employed in the exhaustion) the power of procuring a perfect one. It has also been stated that after the exhaustion of the air, a gas is introduced into the chamber, in order to produce a compensation for the variations in the elastic force of the helical spring, which are consequent upon changes of temperature.

Now, if it be really a fact that a gas is introduced into the chamber after the exhaustion of the air, I cannot, I must confess, comprehend what advantages are expected to be derived from a *particular gas,* in preference to atmospheric air, since it is well known to chemists, that all aeriform bodies whatever, when isolated from liquids, follow the same law in their habitudes with heat, and expand 1-480th part of their volume for each degree of increased heat by Fahrenheit's thermometer. We may therefore infer that the plan to be followed in the preparation of the chamber, is to connect it with the receiver of an air-pump which is provided with a stop-cock and a mercurial gauge. This having been done, the next thing is to proceed with the exhaustion of the receiver until the descent of the mercurial column of the gauge marks that the requisite degree of tenuity has been attained, which has been determined by previous experiment; the chamber is then to be hermetically sealed before it is detached from the air-pump.

The chamber, thus prepared and unconnected with the instrument, has to support the entire weight of the superincumbent atmosphere, and is in consequence closely compressed; therefore, in order to raise it in its frame, a considerable degree of tension is required to be communicated to it by the forcible separation of the corrugated surfaces, because it is a principle of the arrangement to keep them apart. To effect this object, the lower surface is fixed to the plate of its frame by a screw in the centre, and the upper is kept separated from the lower by the power of a lever, which is supported at one end by a fulcrum consisting of two perpendicular pillars upon the plate frame, and at the other end by the tension of the helical spring. The chamber and the spring are so arranged, with regard to their respective distances from the fulcrum, that the spring rises and falls about five times as much as the surface of the chamber, and consequently, by its increased leverage, bears only about one-fifth part of the weight sustained by the chamber.

The annexed diagram will, it is to be hoped, render the preceding, as well as the consecutive part of these remarks, perfectly intelligible.



In considering the action of the Aneroid, it appears to be desirable, for the better comprehension of the subject, to investigate, first—the manner in which the equilibrium is formed between the pressure of the atmosphere and the elasticity of the spring which forms its counterpoise ; and, secondly—to enquire in what way the chamber and the spring are individually affected by the variations of pressure and temperature to which the instrument is exposed,—taking it for granted, of course, that the adjustments for making its scale correspond with that of a standard barometer have been correctly performed.

The chamber and the spring are no sooner placed in the frame, and the forces left free to act, than an equilibrium between them is formed, in which a small amount of the elastic force of the helical spring is, by means of a longer lever, found to sustain the weight of the superincumbent atmosphere pressing upon the chamber, which is supported upon the shorter arm of the same lever. This statement pre-supposes that a perfect vacuum exists in the chamber ; but as this is not strictly the case, the elasticity of the air within must be taken into the account, and the helical spring, in reality, only sustains a weight equal to the difference between the external and internal pressures, or, in other words, equal to the difference of the mercurial columns which each would sustain, when the forces are in equilibrio.*

Let us now suppose the temperature of the air to remain constant, while the pressure varies. In this case we shall perceive that, in proportion as the pressure increases, the surfaces of the chamber are pressed more closely together, and both the lever and the helical spring with which it is connected, must of necessity follow its motion, to restore the equilibrium,—the increased pressure being counterpoised by the increased elasticity of the air in the chamber caused by its compression into a smaller volume, together with the increased tension of the spring by the compression of its coils.

It is necessary to observe, that when the temperature remains constant, the elasticity of the two counterpoises—the air in the chamber, and the spring—increase or diminish together, without any alteration in their original ratio taking place.

---

* The amount of internal pressure may be approximately deduced from the experiment of the author to whom I have before alluded, and whose numbers I employ, not having repeated the experiment. He states that the chamber, from its extent of surface, might be expected to sustain, at 15 lbs. to the square inch, a weight of 73 lbs.; whereas, by positive trial, it supported only 44 lbs. I therefore infer that the difference (29 lbs.) is chiefly supported by the elastic force of the air in the chamber,—minus the small quantity which is probably due to the slight resistance yielded by the thin corrugated copper surfaces. Then, supposing the barometer at the time of the experiment to have been 29·5 inches, we have by proportion—as 73lb : 29lb. : : 29·5 in. : 11·7 in.; which is the probable number of inches the elasticity of the air in the chamber would sustain, and the gauge-point to which the exhaustion of the air-pump should be carried in the preparation of the chamber.

When, however, the atmospheric pressure remains constant, while the temperature varies, the case is very different; for not only is the hand required to continue steadily pointing to the same particular mark upon the dial, but the chamber and the spring, as well as the whole system of levers, must of necessity remain in a quiescent position,—notwithstanding the fact, that the chamber and the spring are varying their relative quantities of elastic force with every change of temperature, and consequently entering into new relations. The problem to be solved, therefore, is, the discovery of the law which these relations are required to follow during these changes.

For this purpose, let us consider what takes place in the counterpoises during an accession of heat.

In the first place, it is necessary to premise that the chamber, being metallic, has a slight increase of capacity from the expansion of its surfaces;—the quantity must, however, be so small, that the consideration of it may be safely neglected, as not affecting our enquiry. But the air within the chamber is very powerfully affected by heat, and when confined over mercury, is found to expand 1-480th part of its volume for each degree of Fahrenheit. And since the extremes of temperature in our climate comprehend a range of more than 50 degrees the expansion must occasionally amount to 1-10th part of its volume;—but as the chamber does not sensibly alter its capacity, that which, if unconfined, would be merely an augmentaion of volume, becomes increased elasticity by confinement. If this additional elastic force were not restrained by some other part of the mechanism, the atmospheric pressure would be more than counterpoised by the increased elasticity of the air in the chamber; and this, alleviating the pressure upon the lever, would allow the spring to rise, and the hand to be carried backward,—were it not that, during the gradual accession of heat which has contributed additional force to the air in the chamber, the spring has been as gradually losing its elastic force by the same increments of heat, and in this manner effects a compensation for temperature, which allows the hand to remain undisturbed amidst the internal changes and variations that are proceeding quietly and without observation.

When, therefore, the pressure is constant, and the temperature is varying, the compensation, if perfect, is effected by the air in the chamber acquiring, by accessions of heat, just so much additional elastic force, as will diminish its pressure upon the lever and the helical spring by an amount precisely equal to the loss of the *spring's elasticity*,—the advantages of leverage being of course considered.

Professor Lloyd, in his report to the British Association, says,—"The indications of the Aneroid have been tested by placing it under the receiver of an air-pump, and observing the action in comparison with the long gauge: they were found to agree to less than 1-100th of an inch." To this I may venture to add, that it is much to be regretted that the distinguished professor did not subject it, at the same time, to the test of temperature; for here it is, as I trust I have succeeded in shewing, that the errors of the instrument are likely to be found,—if it be at all incorrect. I feel persuaded that there are abundant provisions in the instrument for compensation through the limited scale of the common barometric range of about three inches; but, whether perfect compensation can be effected through a more extended scale, requires more accurate experiments than I have hitherto had the opportunity of performing.

While on the subject of temperature it may not be out of place to remark that there are few persons who are not well acquainted with the effects of temperature upon the going of their watches. The discovery is of early date, and was one of the great difficulties which presented itself to be overcome by the early watchmakers. The first intimation of this circumstance was given them upon finding their clocks with seconds pendulums to vary 20 seconds per diem for a rise of about 60 degrees of Fahrenheit. Admirable contrivances for keeping the pendulum always the same length were soon suggested by this discovery. George Graham, in the year 1724, invented the mercurial pendulum now in use,—and Harrison, the gridiron pendulum—so called from its consisting of various rods of metal, the proper combination of which renders the different dilatibility by heat of the two metals composing it the cause of the unchanged length of the whole. No sooner had Harrison produced his timekeeper for the discovery of the longitude at sea, than he met with a new and unexpected difficulty, in the enormous error of his chronometer, arising from extreme changes of temperature, amounting to nearly 7 minutes. No difficulties, however, could repress the ardour nor exhaust the inventive talents of this extraordinary horologian;—for he quickly ascertained that the above error did not proceed from the increased length of the balance spring by heat; but from its loss of *elastic force*, which produced a losing error about seventeen times greater than that depending upon its increased length. The loss of *elastic force* in balance springs by heat was suspected about this period in France (A.D. 1747); as appears by the following passage in the prize essay of Daniel Bernouilli read before the French Academy:—

"I must not omit," said this celebrated geometrician, "a circumstance which may be prejudicial to balance watches: it is, that experimental philosophers pretend to have remarked that certain changes of *elastic force* uniformly follow changes of temperature. If that be the case, the spring can never uniformly govern the balance."*

That which Daniel Bernouilli only conjectured in 1747, was in 1773 established by nice experiments and calculation, and the amount in loss of time due to each of the three conjointly-operating causes determined: namely—

In passing from 32 to 92 deg. Fah.—

Loss per diem by expansion of the diameter of the balance	62 sec.
Do. do. by elongation of the spring ..	19
Do. do. by loss of spring's elastic force	312
	393 s. = 6 m. 33 s.

This important determination, which will, I trust, explain the manner of its action in the Aneroid Barometer, is, on many accounts, a valuable horological record. It shows that a watch without a compensation balance is subject to a losing error of about 6 seconds per diem for each degree of increased heat by Fahrenheit's thermometer. It accounts also for the errors to be observed in pendulums constructed of substances that are scarcely subject to the influence of temperature, such as a deal rod;—for when suspended by a steel spring of an inch in length, the error from the spring alone amounts to about 7½ seconds; and since the error from the spring's direct expansion scarcely exceeds half a second for 60 degrees of Fah., the remaining error of 7 seconds is consequent upon the loss of the spring's *elastic force*. I only speak approximately, in this latter case, as I have these questions under experiment.

If errors, therefore, to such an extent exist from changes of temperature alone, how difficult must it be to produce a chronometer which is required to keep an undeviating rate under every circumstance of position and climate!

---

* This is pretty conclusive evidence that the French had not at that period discovered the compensation balance.

To the invention of John Arnold we are indebted for the perfection of the present marine chronometer. His discovery of the compensation balance,—the peculiar form he gave to his balance spring,—and the admirable construction of his detached escapement, were all based on principles so perfect, that, notwithstanding more than eighty years have elapsed, the most eminent chronometer makers of the present day have declared the whole to be a masterpiece, and the production of a great mind.

Modern experience in the adjustments and general manipulation of the parts, have rendered English chronometers the admiration of both English and Foreign navigators.

Here I cannot refrain from quoting a few lines from Dr. Arnott,—who speaks of having witnessed the performance of these admirable watches, and of the perfection in which they have been produced within the last thirty years, under the name of chronometers, for the purpose of ascertaining the longitude at sea. The Doctor, in reference to the chronometer, writes as follows:—

"But the author may perhaps be excused for mentioning a moment of surprise and delight which he experienced on first seeing their singular perfection actually proved. After months spent in a passage from South America to Asia, his pocket chronometer, with others on board, announced one morning that a certain point of land was then bearing east from the ship at a distance of fifty miles; and in an hour afterwards, when a mist had cleared away, the looker-out on the mast gave the joyous call of 'Land a-head!' verifying the report of the chronometers, almost to a mile, after a voyage of thousands. It is natural, at such a moment, with the dangers and uncertainties of ancient navigation before the mind, to exult in contemplating what man has now achieved. Had the rate of the wonderful little instrument, in all that time, been changed even a little, its announcement would have been worse than useless. But, in the night and in the day—in storm and in calm—in heat and in cold,—while the persons around it were experiencing every vicissitude of mental and bodily condition,—its steady beat went on, keeping exact account of the rolling of the earth and of the stars; and in the midst of the trackless waves it was always ready to tell its magic tale of the very spot of the globe over which it had arrived."

The following table, shewing the effects of temperature upon the Aneroid, has been constructed from the data furnished by the indications of five of them, which were simultaneously subjected to the temperatures stated in the first column, in the same manner as our best watches are tested,—that is, by placing them, for the high temperatures, in an oven provided with the means of regulating the heat; and in an ice-chamber, for the low ones. It may be proper to observe, that, although the Aneroid is only divided to fortieths of an inch, the indications in the table are given much more closely: the readings were taken by estimation, assisted by a powerful glass, and an eye long practised in comparing chronometers.

The Standard Barometer during the trials varied from 29·400 to 29·425, and the temperatures were noted by Fahrenheit's Thermometer.

	No. 987.			1013.			1386.			1608.			1613.		
Fah. Thr.	Inches	Diff.	Cor. for 1°	Inches	Diff.	Correctn.	Inches	Diff.	Correctn.	Inches	Diff.	Correctn.	Inches	Diff.	Correctn.
60°	29·452			29.380			29·452			29·470			29·470		
100	29·510	+·058	—·00145	29·480	+·100	—·00250	29·575	+·125	—·00312	29·555	+·085	—·00212	29·557	+·087	—·00217
55	29·425	—·085	—·00189	29·420	—·060	—·00183	29·448	—·127	—·00282	29·448	—·107	—·00238	29·450	—·107	—·00238
115	29·500	+·075	—·00126	29·555	+·135	—·00225	29·625	+·177	—·00295	29·620	+·172	—·00287	29·648	+·198	—·00330
49	29·448	—·052	—·00079	29·420	—·135	—·00204	29·445	—·180	—00·273	29·455	—·165	—·00250	29·450	—·198	—·00300
85	29·530	+·082	—·00227	29·548	+·128	—·00355	29·600	+·215	—00·597	29·595	+·140	—·00398	29·580	+·130	—·00360
35	29·465	—·065	—·00130	29·430	—·118	—·00236	29·450	—·150	—·00300	29·470	—.125	—·00250	29·440	—·140	—00·280
	Mean cor. for 1°—·0015			Mean correctn. —·0025			Mean correctn. —·0034			Mean correctn. —·0027			Mean correctn. —·0029		

N.B.—The numbers in the third column are obtained by dividing the differences in the second column by the differences of the temperatures—thus: $\frac{\cdot 058}{100^\circ - 40^\circ} = \cdot 00145$; and the mean correction is the sum of the numbers in the third column divided by 6.

It will be seen from the foregoing table that the deviation for a change of 30 or 40 degrees of Fahrenheit, is about 1-10th of an inch. In the above five instruments the error is in excess, and the correction of course minus, for temperatures above the mean, and plus for those below; but it is probable some may have the opposite error. When the proper correction has been determined by a few careful trials, the Aneroid will, no doubt, be found to ascertain heights to a surprising degree of accuracy.

These slight deviations detected in the Aneroid ought not to be considered as detracting from its accuracy; for it is very evident the errors follow a determinate law of increase; and it consequently becomes a question of importance, as to whether some simple means of adjustment for temperature might not be found, which would not impair the present almost perfect state of the instrument. Be this, however, as it may: the public will not, I presume, appreciate the instrument the less for general purposes, because a slight deviation has been discovered in it, which must not be unnoticed when employed for philosophical experiments; and assuredly men of science will look upon it with less distrust when they find that it has been ascertained by accurate experiments (which, in fact, they can easily repeat for themselves) within what assignable degree of exactness its determinations may be relied on.*

The uses to which the Aneroid may be applied are the same as those of the barometer; but the former is, on account of its portability, much less restricted in its employment than the latter. The Aneroid, as a popular instrument, has also an advantage peculiar to itself, which will incline many persons to give it the preference. When employed, for instance, in the admeasurement of heights, it has the property of giving at once the required information in feet, approximately, by merely allowing ninety feet every tenth of an inch the index goes back, and nine for every hundredth.

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* Copper is usually classed among the non-elastic metals. It becomes, however, a subject of curious speculation and enquiry, whether the trifling loss of elasticity, and increased capacity of the chamber, will not account for the minute discrepancies observed on comparing the Aneroid, through a long range of temperatures, with a standard barometer.

If, however, a greater degree of accuracy is required, a very near approximation may be obtained by employing the following table, calculated from the formula of Sir G. Shuckburgh.

Inches.	Feet.
26·0	3926
26·5	3406
27·0	2895
27·5	2392
27·6	2293
27·7	2194
27·8	2095
27·9	1996
28·0	1897
28·1	1799
28·2	1702
28·3	1605
28·4	1508
28·5	1411
28·6	1315
28·7	1219
28·8	1123
28·9	1028
29·0	933
29·1	838
29·2	744
29·3	650
29·4	556
29·5	462
29·6	368
29·7	276
29·8	184
29·9	92
30·0	0

Use of the Table.

Observe the indications of the Aneroid at the bottom, and again at the top of the elevation of which you desire to know the height.

Take out from the table the number of feet corresponding to the lesser of the two pressures, omitting the hundredths of the Aneroid reading, and from this number subtract the feet corresponding with the other reading, diminished also by the hundredths omitted in the other number, allowing the proportional part for the hundredths between the numbers given in the table, and the result is the height sought.

Example. Required the height of an elevation, the hand of the Aneroid indicating at the bottom a pressure of 29·53, and at the top 28·48?

28·48—·08=28·4 - - - - - - - - 1508 feet

$$2953 - \cdot08 = 29\cdot45 \text{ then } \left.\begin{array}{r} 29\cdot4 = 556 \text{ ft.} \\ \cdot05 = +47 \text{ ft.} \end{array}\right\} 603 \text{ feet}$$

Altitude required 905 feet

In carrying a barometer from the level of the Thames to the top of St. Paul's Church, in London, or of Hampstead Hill, the mercury falls about half an inch, making an ascent of about 500 feet;—on Mount Blanc it falls to half of the entire barometric height, making an elevation of 15,000 feet;—and in Du Luc's famous balloon ascent, it fell to below twelve inches, indicating an elevation of 21,000 feet, or nearly four miles—the greatest to which man has ever ascended from the surface of his earthly habitation.

Water at the top of Mount Blanc boils at 180 deg., because relieved from the pressure of the air that is below the level of the mountain's summit; and at all intermediate heights, in descending to the level of the sea, and beyond that, into mines, there is a corresponding increase of the boiling temperature. So exactly is this the case, that we now find it to be a good method of ascertaining the heights of places, merely to observe the heat of boiling water at them.

To many persons, the information here given, that boiling water is not equally hot in all places, will appear extraordinary: and they will now understand that, even in the same place, at different times, when the barometer is high or low, there will be corresponding differences.

To nautical men the Aneroid will be found of great value, as a companion to the marine barometer; not only from its great sensitiveness to atmospheric changes, but from its not being in a material degree affected by the ship's motion.

REMARKS ON THE BAROMETER, BY

P. CHRISTENSEN.

The column of air over the barometer is exactly counterbalanced by the column of mercury in the tube of the same diameter.

The pressure of the atmosphere is from 14 to 15 lbs. upon every square inch, or 8 oz. for each inch of mercury in the tube.

The rising or sinking of the mercury shows the alterations of the weight of the atmosphere.

The gradual rising of the mercury indicates a continuance of fair weather, because the air being heavier than the vapours floating in it, will cause them to ascend to the upper regions. The reverse takes place when the air is lighter, which will be indicated by the sinking of the mercury.

Although the perpendicular column of the atmosphere may be heavy enough to support even thirty inches of mercury, yet the lower region may be so rarefied as to allow the vapours to descend; in still weather the mutual attraction will increase the size of the drops in their descent, but in this case a diligent observer will have timely notice by the upper part of the mercury becoming CONCAVE. On the contrary, the atmospheric column may be too light to support twenty-nine inches of mercury, and yet the lower region may be condensed to a degree sufficient to keep the vapours in a state of buoyancy; this may be known by the surface of the mercury becoming CONVEX.

The whole range of the mercury seldom exceeds half an inch between the tropics, but from the tropics to the polar circles it amounts to three, and sometimes (but rarely) to three inches and a half; from thence to the poles the range is again diminished to nearly a quarter of an inch.

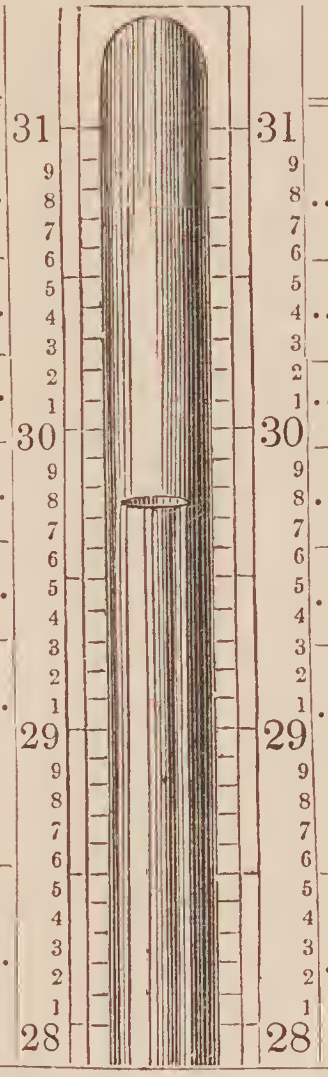
The following may not be uninteresting to the inquirer after meteorological science :

At Lymington, in Hampshire ..	from	1808 to 1816	mean altitude	29	in.	83	hunds
At Yarmouth, Isle of Wight ..	,,	1817 to 1829	,,	29	,,	81	,,
At Newport, Isle of Wight	,,	1830 to 1835	,,	29	,,	96	,,
At Cowes, Isle of Wight	,,	1836 to 1839	,,	29	,,	90	,,
Ditto ditto............	,,	1840 to 1845	,,	29	,,	85	,,

Mean altitude during 38 years 29·87.

☞ The Author during the last seven years' observation, viz: from 1839 to the end of 1846, has not found any reason to alter a single figure in the Table, and has therefore divided the range of the mercury into compartments in the eleventh, and present edition, and reduced it to the mean of the year.

Companion to the Barometer, constructed from 32 years' observation on that valuable instrument, by P. Christensen, Lecturer on Magnetism, Optics, Astronomy, &c., &c., Cowes, Isle of Wight.



DESCENDING SCALE.	ASCENDING SCALE.
Fine settled Weather ...	...Very Dry
Fair ...	...Settled Fair
Inclining to Change ...	...Fair
Changeable ...	...Inclining to Fair
Rain ...	...Variable
Windy with Rain ...	...Moderating ...
Strong Gale ...	...Stormy ...

☞ Observe the altitude of the Mercury at least three times a day, and oftener if convenient.

Particular attention must be paid to the movement of the Mercury, viz., if RISING since last observation, the prognostication of the weather will be found in the right-hand column, marked ASCENDING SCALE, but if SINKING, it will be found in the left-hand column, marked DESCENDING SCALE.

N.B.—If the wind is from ESE to NNW points of the compass, it will increase the height of the Mercury; and with the wind from W to S the mercury will be depressed.

Alternate rising and sinking of the mercury in the course of a few hours, indicates unsettled weather.

The above is constructed from observations taken at thirty feet above the level of the sea—for every ten feet above thirty, add one-hundredth part of an inch to the altitude of the mercury.

OBSERVATIONS ON THE

MERCURIAL BAROMETER.

As a correct and standard indicator of the various changes in the pressure of the atmosphere, the mercurial column as applied in the upright barometer, must doubtless be acknowledged as the only standard of reference and comparison for all other kinds of barometer. It was discovered by Torricelli about the year 1640, by the mere balancing of a column of mercury against the varying weight or elasticity of the air. Nature, in this instance, appears to have communicated at once, to this great philosopher, an existing principle so perfect, that beyond various interesting modifications in its construction and form, every attempt to improve it during the last two centuries has proved abortive. Nor is the admirable simplicity of the barometer less astonishing than the perfection of its principle; for while we find that our atmosphere gives an average pressure of 15 lbs. upon every square inch of surface, we also find this atmosphere to balance a column of mercury of 30 inches perpendicular altitude, and that the removal of every pound of pressure of air from its surface, whether by natural or artificial means causes a descent of the mercurial column of exactly two inches, and *vice versa.*

The barometer is applied to a variety of important purposes both by land and sea—it guides the agriculturist in his labours, assists the engineer in regulating the speed and power of his ingenious mechanism, determines the height of mountains for the tourist, and warns the mariner of impending danger by the timely notice of the approaching storm; thus giving him the opportunity of employing the means which may avert its terrible consequences. Services such as these must infallibly shew the necessity of an instrument at once simple, accurate, permanently correct, easily understood, and above all, one which can be readily tested by the observer, and known to be correct and in proper action; and in the barometer this can be done by the easy process of applying a scale of inches to the mercurial column, and noting the height above the level of the mercury in the cistern which, in a correct instrument, will be found to correspond with the indication upon the engraved scale. The union of all these valuable properties exists only in the mercurial barometer, and so many advantages in one instrument would render any other kind of barometer superfluous were it not that a smaller and more portable instrument is in many instances advantageous, and in this respect the Aneroid becomes an interesting addition to the list of meteorological instruments, and to science. While, however, we award to this ingenious instrument its full share of merit for the ability displayed in its mechanical contrivance, easy portability, sensitiveness, &c., we are constrained to regard it as a second-rate instrument only, from the fact that there are no ready means of ascertaining at any desired moment its degree of correctness but by comparison with a standard barometer, and this will, at best, only show their correspondence at that particular part of the scale where the hand may be at the time of comparison, and can afford no guarantee that they will correspond throughout the range. It is necessary also, before placing too great reliance upon this new instrument, to enquire what effects time and moisture are likely to have upon the elasticity of the metals of which it is composed, and whether it may not be susceptible of serious derangement from their gradual oxydation.

To the meteorologist, mariner, agriculturist and engineer, where actual use is the real object of the instrument, there cannot, I think, arise a doubt as to which is the instrument for them; but for the tourist, to whom portability is a great consideration, the Aneroid certainly claims attention as it possesses this property in an eminent degree.

In order to form a just opinion of the instrument, I was led to inquire whether the indications of the Aneroid upon its own graduated scale were perfectly regular, and how far they corresponded with the Mercurial Barometer. Those I have tried were found to be exceedingly sensitive, and to agree well enough therewith within the ordinary range of the barometer, from 28 to 31 inches, but upon reducing the pressure to 26 inches, there was a variation of about two tenths of an inch upon an average, and the variation increased as the pressure was diminished: such errors must lead to serious inaccuracies in measuring heights by the Aneroid.

For nautical use, I may be allowed to remark that however agreeable the Aneroid may be as an auxiliary to the barometer, or pleasant, as some writers have observed for the captain to carry it from the cabin to the deck and the like, still it should be remembered, that choice should be made, not of that instrument which notes the passage of every heavy cloud over our heads, but that which gives the longest and steadiest notice of the approaching storm.

The marine barometer as has been shown is subject to no derangement but what the captain may readily detect, but the Aneroid is utterly incapable of being so tested, nor are there any means of knowing either where or to what extent derangement may exist: few captains will therefore, I should imagine, voluntarily trust themselves to such an instrument alone.

The Marine Barometer in its general appearance is probably familiar to most of our readers. Besides the arrangement for insuring its perpendicularity under every position of the ship, it has another of equal importance in the proper construction of its tube. The upper part, to the extent of its scale shews the ordinary sized column of mercury, but below this, a stout tube, much smaller in the bore, is continued down to the cistern. This arrangement prevents the oscillation of the mercury by the tossing of the ship, and preserves the instrument from injury by any sudden jerk of the mercurial column against the top of the tube. Practical men have succeeded in discovering the limit to which the reduction of the aperture of the tube may be carried, so as to insure the safety of the instrument without impeding the free flow of the mercury, or impairing the susceptibility of the instrument to denote the slightest atmospheric changes; nor do I think there is one instance upon record of a well constructed instrument shewing a diminution in sensitiveness in comparison with the most accurate standard barometer.

The diversity and importance of meteorological observations have, from time to time, suggested numerous plans for extending and elongating, or rather magnifying the divisions of the barometrical scale. The water barometer at the Royal Society is about forty feet high, and has a scale of about one foot to the inch as compared with the mercurial column. In the Philosophical Transactions, 427, Rowney speaks of one, the scale of which he says may be expanded *ad infinitum*. Dr. Hook, in the dial barometer in common use has greatly extended its scale. Descartes also by means of two tubes containing fluids of different densities amplifies the scale at pleasure from two to twelve inches to the foot, notwithstanding the instrument itself is not more than thirty-eight inches long. This instrument is little known, but I frequently make them, and have always some in my possession.

The Sympiesometer from its convenient portability on ship board, and from its capability of being made to any size or scale, though ordinarily about twenty-three inches long and three wide, with a scale of from two to three inches to the inch, has been much employed as an auxiliary to the marine barometer; yet, notwithstanding its construction has been so far improved as to combine much permanency of adjustment with great accuracy, sensitiveness, hardihood and durability, it is generally characterised as being too unsteady and sudden in its movements to be exclusively relied on. This instrument, too, like all others, must entirely depend upon the mercurial barometer for comparison and adjustment, in the same manner as a clock or watch upon a proper regulator, and this in its turn, upon nature itself.

The marine, mountain and upright house barometers are made in that neat and portable form, that when packed in hay with ordinary care, they are sent with perfect safety to all parts of the world.